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THE ATMOSPHERIC TRANSMISSION GENERATION SYSTEM FOR SATELLITE INFRARED SOUNDERS

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JULY 1981

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The Atmospheric Transmission Generation System is a collection of computer programs which generate atmospheric transmission profiles for satellite-borne infrared sounders. Some of this system's components have been used to produce a monochromatic transmittance tape (MTT) which covers the spectral range from 640-780 cm^{-1} with a resolution of 0.1 cm^{-1}. The MTT can be used in conjunction with other programs in this system to quickly and easily produce spectral atmospheric transmission profiles, which can subsequently be used for temperature retrievals.

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INTRODUCTION

Most physical temperature retrieval algorithms solve the radiative transfer equation using a guess temperature profile, then adjust the guess profile until the computed radiances agree with the observed radiances. Atmospheric transmission profiles are a prime requirement for the solution of the radiative transfer equation. The Atmospheric Transmission Generation System (ATGS) is a collection of computer programs which generate atmospheric transmission profiles for satellite borne infrared sounders.

The programs comprising the ATGS are divided into four classes:

(1) Monochromatic Transmission Programs

(2) Spectral Transmission Programs

(3) Transmission Tuning Programs

(4) Utility Programs

The Monochromatic Transmission Programs compute monochromatic transmittances with a given spectral resolution. These programs have been used to produce a Monochromatic Transmittance Tape (MTT) which covers the interval from 640-780 cm^{-1} with a spectral resolution of 0.1 cm^{-1}. The MTT can be used to generate spectral transmittance using the Spectral Transmission Programs and the Transmission Tuning Programs for any infrared sounder whose spectral characteristics fall within the range from 640-780 cm^{-1}. If a spectral response outside of this range is to be considered, then the Monochromatic Transmission Programs need again be utilized. Furthermore, if transmission in the 4.3 μm CO_2 absorption band is to be computed, a different continuum must be used. The Utility Programs are a collection of programs which assist in various cataloging and quality control operations. The prospective user should contact the author for access to the ATGS.

1. MONOCHROMATIC TRANSMISSION PROGRAMS

The Monochromatic Transmission Programs generate the Monochromatic Transmittance Tape (MTT). The MTT contains atmospheric transmittances averaged over .1 cm^{-1} for the spectral region 640-780 cm^{-1}. Transmittances are computed for the five standard atmospheres and for fifteen zenith angles listed in Table 1. These programs will have to be run again only if there are transmissivity requirements other than those specified in Table 1.

Table 1a. Standard atmospheres used in the Monochromatic Transmittance Tape.

1. Tropical
2. 30° Summer
3. 30° Winter
4. 60° Summer
5. 60° Winter

Table 1b. Zenith angles used in the Monochromatic Transmittance Tape.

1.	0°	6.	35.0°	11.	50.0°
2.	10°	7.	40.0°	12.	52.5°
3.	20°	8.	42.5°	13.	55.0°
4.	25°	9.	45.0°	14.	57.5°
5.	30°	10.	47.5°	15.	60.0°

1.1 PROGRAM HITRAN

HITRAN is a modification of program FLLIN by R. A. McClatchey et al. (1973) at the Air Force Geophysics Laboratory (AFGL) (indeed it is still called FLLIN on the program card). It is designed to compute spectral transmittances integrated over an input discrete value filter response function. The program was modified to read in a number of filter functions and stage them to disk for subsequent use. For the purposes of this project the filters are .1 cm^{-1} wide with a spectral response of unity over the entire interval.

The spectral intervals are set by the utility program SETFRQ, and incorporated into the input data stream by interactive editing. Due to the large amount of computation which is performed, most of the output statements have been commented out.

1.1.1 Main Program

The main program reads input cards and acts as the driver. It has the capability to process any of nine model atmospheres. The model atmospheres contain pressure, temperature and ozone molecular burden. The model atmospheres are listed in Table 2.

Table 2. Model atmospheres available to HITRAN.

1. Tropical Annual
2. 30° Summer
3. 30° Winter
4. 45° Summer
5. 45° Winter
6. 60° Summer
7. 60° Winter
8. 75° Summer
9. 75° Winter

Note that Table 2 is more extensive than Table 1a.

The card input to the program is as follows:

Card Set A: First 51 cards - water vapor continuum table
FORMAT (14X, F5.0, 3E13.4, F9.2)

Card Set B: (1 card) DEPTH, SWING, FORMAT (2E10.3)
DEPTH - optical depth
SWING - molecular rejection criterion

Card Set C (1 card) NMODL, ISMDL, INMDL, ZA FORMAT (3I3,F10.3)
NMODL - total number of standard atmospheres to read, including those to be rejected
ISMDL - starting atmosphere to process - earlier ones are rejected
INMDL - ending atmosphere to process
ZA - local zenith angle

Card Set D: (1 card)	NFREQ. FORMAT (I5) number of filter functions to process
Card Set E: (Variable number of cards	There will be NFREQ sets of the following cards:

VA1, VA2, ADV, VCF FORMAT (2F10.3,F10.4,F10.3)

VA1 - starting frequency of this filter

VA2 - ending frequency of this filter

ADV - frequency increment of this filter

VCF - central frequency of this filter (for labeling purposes only)

FIL - filter response values

NP1 - number of elements in this filter computed from VA1, VA2 and ADV

For this problem, VA1 and VA2 are set .1 cm^{-1} apart, and ADV is .05. This means that NP1 will be three, and that the three elements of elements of FIL will be unity. These filter values are generated by program SETFRQ and incorporated into the data stream by interactive editing.

Card Set F: (9 sets of 70 cards)

Next are the nine model atmospheres, with one set for each atmosphere.

ITP, DV, BOUND, VBOT, VTOP FORMAT (I3,4F10.3)

ITP - number of levels in the atmosphere = 70

DV - integrating interval for transmittance output = .1

BOUND - limits for far wing computations of distant lines = 30

VBOT - lowest filter frequency - BOUND

VTOP - highest filter frequency + BOUND

P(K), W(1,K), W(3,K), T(K), K = 1,ITP

FORMAT (F10.4,2E15.4,F10.3)

P(K) - pressure (mb)

W(1,K) - water vapor molecular burden = 0.0

W(3,K) - ozone molecular burden

T(K) - temperature °K

The filter functions are all read and written to disk for later access. The AFGL Atmospheric Absorption Line Parameter tape (see McClatchey et al., 1973) is read and the important line parameters are also written to disk by subroutine RDTAPE. For each atmosphere the filter functions are read and processed. The call to subroutine ATMLYR performs the actual computation of transmittance for each filter. The transmittance profile for each filter is then output to disk. For the spectral region 640-780 cm^{-1} there are thus 1400 records output. Each record is in effect the monochromatic transmittance averaged over a .1 cm^{-1} interval.

1.1.2 Subroutine ATMLYR

ATMLYR performs the actual computation of transmittance. It first calls subroutine RDTAPE to select the absorption line data and stores it in core for high speed access. The major loop in this subroutine is on the layers of the atmosphere. The transmittance for each layer is computed by summing the attenuation due to each absorption line within the bounds of the filter, and the far wings of lines near the edge of the filter. A Lorentzian line shape is used throughout. The filter function is convoluted by subroutine AFILT, and the water vapor continuum is computed by subroutine CONT.

1.1.3 Subroutine RDTAPE

RDTAPE has two functions. The first function, activated by a call from the main program, is to read the binary line structure tape, select the data for the frequency interval of interest, and stage this data to a disk file. The second function, activated by calls from subroutine ATMLYR reads this disk file, finds the largest line strength for each frequency region, and stores in core the line parameters for the lines with strengths within three orders of magnitude of this maximum strength.

1.1.4 Subroutine AFILT

AFILT interpolates between the discrete points of the filter functions to get the value of the filter at an intermediate point.

1.1.5 Subroutine CONT

CONT computes the attenuation due to the water vapor continuum as a function of specified frequency.

1.1.6 Subroutine ERR

ERR prints an error message specifying the type of error, and suggests remedial action if necessary. Five kinds of errors can be flagged by different calls to ERR.

1.2 PROGRAM DIDLTAU

The output format of HITRAN is dictated by the physics of the problem, but is not convenient for efficient data access. HITRAN outputs one record for each spectral interval, or 1400 records. Each record contains the transmittance profile for that spectral interval as well as other ancillary information. DIDLTAU reads the HITRAN output, stages only the pertinent data to ECS, and writes this data to disk in a more organized format. The new format is sixty-nine groups of 1400 records. The records in this case are composed of level number, frequency and transmissivity. Each group of records represents one level. File positioning must be done with control cards.

1.3 PROGRAM TRANTP

TRANTP creates the monochromatic transmittance tape from the DIDLTAU output. The tape consists of the transmittance from a given pressure level to the top of the atmosphere for every .1 cm^{-1} over the spectral region from 640 to 779.9 cm^{-1}. Each record will consist of all of the monochromatic transmittances from one atmospheric level. The transmittances are truncated to nine digit accuracy and put into thirty-bit bytes, and packed two values to the sixty bit word. Each record will be 700 words long. There

are seventy levels per atmosphere, and 5 atmospheres (350 records) per file. The topmost level (first record) is extrapolated from those below it. The tape has fifteen files, one per zenith angle. File positioning is done by control cards.

2. SPECTRAL TRANSMISSION PROGRAMS

The Spectral Transmission Programs read the monochromatic transmittance tape and produce spectral transmittances for a given instrument response function. They also perform the final tuning of the transmittances and load them to a ZRANDIO file for operational retrieval processing at FNOC.

2.1 PROGRAM SPECTRN

SPECTRN computes spectral transmittances from the MTT for a given instrument response function. Spectral transmittance is given by

$$\tau^* = \frac{\int_{\nu_1}^{\nu_2} \phi(\nu)\tau(\nu)d\nu}{\int_{\nu_1}^{\nu_2} \phi(\nu)d\nu} \tag{1}$$

where

τ^* is the spectral transmittance,

$\tau(\nu)$ is the monochromatic transmittance from the MTT,

$\phi(\nu)$ is the instrument response function, and

ν_1 and ν_2 are the lower and upper limits respectively of the instrument response function.

The filter functions are read from input unit TAPE1 in the following manner:

V1, V2, DV, VCF FORMAT (2F10.3, F10.4, F10.3)

- V1 Starting frequency of filter
- V2 Ending frequency of filter
- DV Frequency increment between filter elements
- VCF Filter central frequency (for labeling purposes only)

FIL(J), J=1,NP FORMAT (9F8.4)

- FIL(J) Discrete value filter response function. Must be equally spaced in frequency
- NP Number of discrete points in filter. Calculated from V1, V2 and DV.

SPECTRN expects six sets of cards, one for each channel of the SSH instrument flown on the DMSP satellites. Up to 210 discrete points are allowed for each filter on input.

After the filter functions are read in, they are interpolated to every .1 cm^{-1} to correspond with the resolution of the MTT. Next the integral of each filter function is computed using subroutine SIMPSON for use in the denominator of Eq. (1).

One level of monochromatic transmittance is then read from input unit TAPE2 and unpacked. The location of each filter's bounds in the monochromatic transmittance array is computed to eliminate unnecessary computations in the quadrature. The numerator of Eq. (1) is computed for each filter. Finally this value is normalized by the integral of the filter function to yield the spectral transmittance for each filter for this level of this atmosphere. This procedure is repeated for all seventy levels of each atmosphere. The program is set to process seventy-five cases; five atmospheres and fifteen zenith angles for each atmosphere. The spectral transmittances for each case are written to output unit TAPE3 as a 6x70 array using BUFFIO.

2.1.1 Subroutine INTFIL

INTFIL interpolates a given instrument response function with a given increment to .1 cm^{-1} increment. This is done to greatly simplify the quadrature in the numerator of Eq. (1).

2.1.2 Subroutine SIMPSON

SIMPSON is a routine resident on TJKLIB,ID=KL which performs SIMPSON's integration on any discrete valued equispaced function. Since the SIMPSON integration technique requires an even number of points, a provision has been added for an odd number of points. If this is the case, an extra point is linearly extrapolated from the previous two, the area of the last interval is computed, and half of this final interval area is added to the sum. In the case of the filter functions, the values at the endpoints are very small compared to the peak values, so any error introduced by this variation would be very minor.

2.2 PROGRAM ZTAU

All of the programs described thus far use FORTRAN I/O or BUFFIO for ease of operation. However, the operational retrieval package on the SPC uses ZRANDIO. Thus it is necessary for one final program to convert the data written by BUFFIO to ZRANDIO format. ZTAU performs this function. The program is set to process up to nine atmospheres of data. It expects the input spectral transmittances to be organized in fifteen groups of data, one for each zenith angle, and all of the atmospheres within each zenith angle group. Of course, this format is conveniently the SPECTRN output format. The spectral transmittances are read from unit TAPE1. The number of atmospheres to process (normally 5) is set in DATA statement. The ZRANDIO record names are also set in DATA statement.

ZTAU also performs a second function, which is to apply the tuning factor to the data before putting into ZRANDIO files. The tuning philosophy is described in Section 3. The tuning parameters are read from logical unit TAPE2 in FORMAT(6F5.2). There is a different tuning parameter (epsilon) for every channel and for each atmosphere. Just before the transmittances are written to ZRANDIO, they are raised to the epsilon power. The ZRANDIO output is arranged such that all fifteen zenith angles are grouped together for each atmosphere.

3. TRANSMISSIVITY TUNING PROGRAMS

Modeling of atmospheric transmission is an inexact science. Retrievals performed with spectral transmissivities produced by the above described programs have demonstrated a necessity to tune the transmittances with real data. This is done by collecting a set of coincident satellite and clear column radiosonde observations. The observed radiances are compared with synthetic radiances computed from the radiosonde profile, and the transmissivities are adjusted by raising them to some power epsilon until the radiances are in good agreement. Epsilon is determined by an iterative procedure. The "best" value for epsilon is bracketed within some interval, and then the interval is further subdivided to refine the value. Epsilon is chosen to be a function of standard atmosphere as well as channel.

3.1 PROGRAM SATRAOB

SATRAOB looks for coincidences between satellite observations and radiosonde observations. Internal to the program is the location of preselected coastal and island radiosonde stations, chosen such that the satellite will always pass near them within one hour of synoptic time. The program is presently coded to store up to fifty station locations. The stations with no clouds are determined by examining the satellite imagery on the SPADS. The list of clear column station indices corresponding to the station locations in storage are read from logical unit TAPE1 with FORMAT(I3). The packed earth located calibrated radiances, which are an optional output of the operational retrieval package, are read from logical unit TAPE2 using BUFFIO. The program unpacks the location of each radiance observation and tests if it is within one degree of latitude and longitude of any clear column station. If so, it verifies that the observation is not over a land mass, and is within one hour of synoptic time. When the observation passes all of these tests, it is defined to be in coincidence with a radiosonde station, assuming that the radiosonde observation was

taken. Pertinent data are extracted from the satellite observation and an eleven word record is written to logical unit TAPE3. The contents of this record are listed in Table 3.

Table 3. Contents of Satellite Coincidence Record Output by SATRAOB.

Word	Contents
1	Identifier - 12MSB = station index number 48LSB = Julian time of year in minutes of nearest synoptic time to satellite observation time
2	Latitude of observation (*100)
3	Longitude of observation (*100)
4	Nadir angle of observation (Radians *1000)
5-11	Radiances *100 for CH1-7, with CH7 being the window

Note: All words are type integer. A coincidence is indicated by word one of this record being identical with word one the Radiosonde Coincidence Record output by GETRAOB.

3.2 PROGRAM GETRAOB

GETRAOB was written to search the FNOC data base for specified radiosonde stations. The radiosondes to be selected are coastal and island radiosondes which are located such that the satellite in sun synchronous orbit always passes near them within one hour of synoptic time. The program is presently set to accept fifty such stations. The integer array IRMN is the storage for the station designators. Once found, the radiosonde profile is interpolated to seventy standard levels, equally spaced in p^k. The RAOB is then written out in the format defined in Table 4.

Table 4. Contents of Radiosonde Coincidence Record Output by GETRAOB.

Word	Contents
1	Identifier - 12MSB = station index numbers 48LSB = Julian time of year in minutes of nearest synoptic time to satellite observation time
2-30	RAOB report interpolated seventy standard levels equally spaced in p^k, ordered from top of atmosphere down 144 - 12 bit bytes Bytes 1-72 Temperature (°K)*10 Bytes 73-144 Water mixing ratio (PPT)*100.

Note: All words are type integer. A coincidence is indicated by word one of this record being identical with word one of the Satellite Coincident Record Output by SATRAOB.

3.2.1 Subroutine PROFL

PROFL interpolates the radiosonde profile to seventy standard levels equally spaced in $(\text{pressure})^{2/7}$. The standard levels are given in Table 5. It also converts dew point depression to water vapor mixing ratio.

Table 5. Standard pressure levels used by PROFL.

Level	Pressure	Level	Pressure
1	.01	36	105.280
2	.030	37	115.390
3	.070	38	126.170
4	.140	39	137.660
5	.250	40	149.870
6	.400	41	162.840
7	.620	42	176.600
8	.900	43	191.160
9	1.270	44	206.560
10	1.740	45	222.830
11	2.320	46	239.990
12	3.030	47	258.080
13	3.880	48	277.120
14	4.890	49	297.140
15	6.070	50	318.180
16	7.440	51	340.250
17	9.020	52	363.410
18	10.830	53	387.660
19	12.890	54	413.050
20	15.200	55	439.610
21	17.800	56	467.360
22	20.710	57	496.340
23	23.930	58	526.590
24	27.500	59	558.130
25	31.440	60	590.990
26	35.760	61	625.220
27	40.490	62	660.840
28	45.650	63	697.880
29	51.270	64	736.390
30	57.360	65	776.390
31	63.960	66	817.910
32	71.070	67	861.000
33	78.740	68	905.690
34	86.980	69	952.010
35	95.820	70	1000.000

3.3 PROGRAM MRGOBS

MRGOBS reads the Radiosonde Coincident file from program GETRAOB, and the Satellite Coincident file from program SATRAOB; matches up the observations; and outputs merged satellite-radiosonde coincident observations. It is possible that several satellite observations may be coincident with a given radiosonde observation. Therefore provisions are made for up to ten satellite observations to be coicident to a given radiosonde observation. The first thirty words of the output record are identical to the contents of the Radiosonde Coincident Record (see Table 4). The remainder of the output record contains the contents of the Satellite Coincident Record(s) (see Table 3) which correspond to that Radiosonde Coincident Record. The resulting Merged Coincident Record will be a variable length record with 41, 52, 63, ..., 140 words. Since the Merged Coincident Record is written using BUFFIO, it is simple to determine the number of satellite observations in the coincidence by invoking the LENGTH function immediately after the UNIT check on input.

3.4 PROGRAM TUNTAU

TUNTAU is the final program of the Transmission Tuning Programs. It is used to establish the tuning parameter for the DMSP transmissivities. This is done by raising the transmissivities to some power epsilon, computing the outgoing radiances for a collection of clear column radiosonde, and computing the error statistics when compared with coincident radiance measurements from the satellite. Epsilon is a function of five atmospheres and six channels. Epsilon is incremented ten times from an initial value in order to bracket the correct value. It will be necessary to run this program several times, using different initial values and different increments in order to narrow down the "best" estimate of epsilon for each atmosphere/channel combination.

The Merged Coincident File is read from logical unit TAPE1 using BUFFIO. The initial values for epsilon and their corresponding displacements are read from logical unit TAPE2 using FORMAT(6F5.2). The spectral transmissivities, which were output by program ZTAU, are read using ZRANDIO. The ZRANDIO record names are set in BLOCK DATA STDATMS along with the central frequencies of the channels. A print option which will cause all of the computed and observed radiances to be printed out can be set in the main program. The output is a list of mean errors and standard errors for each channel and each atmosphere for each of the ten epsilons. After the final values for epsilon are decided upon, they are input to ZTAU for the determination of the final spectral transmittances for the operational retrieval package.

3.4.1 Subroutine INIT

INIT performs initialization for TUNTAU. On the first call it zero's the statistics arrays, initializes the coefficients for the Planck equation (Eq. 3), reads the spectral transmittances from ZRANDIO and loads them into ECS. Subsequent calls to INIT merely initialize the arrays.

3.4.2 Subroutine MIX

MIX calculates the profiles of the moisture parameters from the seventy level mixing ratio profile. Three water vapor associated quantities are calculated; 1) precipitable water, 2) the (pressure-temperature)$^{1/2}$ weighted precipitable water for the continuum correction, and 3) the (pressure-temperature)$^{1/5}$ weighted mixing ratio squared for the dimer correction.

3.4.3 Subroutine OUTPT

OUTPT computes the statistics for the coincidences and prints the result in an attractive format. The statistics computed are the mean and standard deviation of the measured radiances, the computed radiances and the difference between measured and computed.

3.4.4 Subroutine RADCOMP

RADCOMP solves the radiative transfer equation

$$N(\nu) = B(\nu,T(p_0))\tau(\nu,p_0) + \int_{p_0}^{0} B(\nu,T(p))\frac{\partial\tau(\nu,p)}{\partial p}\,dp, \qquad (2)$$

where

N is the outgoing radiance,

$$B = \frac{c_1\nu^3}{\exp(\frac{c_2\nu}{T})-1} \text{ is the Planck equation,} \qquad (3)$$

ν is the representative frequency of the channel,

T is the temperature,

p is the pressure,

c_1 and c_2 are constants.

The subscript zero refers to the surface.

The surface temperature is assumed to be that of the bottom most layer temperature. The effects of water vapor attenuation and the water vapor continuum are taken into effect in the transmission computation. Finally, running sums are kept of the measured radiance, the computed radiance, and the difference as well as the squares of these quantities.

3.4.5 Subroutine RDMRG

RDMRG reads and unpacks one record of the Merged Coincident File. It has two parameters, KT and JFLG. On the initial call to RDMRG, KT is set to zero and one record is read in and the radiosonde data is unpacked. The number of satellite observations coincident with the radiosonde determines the record length (see Section 3.3). KT is initialized to this number. On subsequent calls to RDMRG, KT is tested for nonzero value. If it is nonzero, there are more satellite observations to unpack, so the read operation is skipped, the next satellite observation is unpacked and KT is decremented. This procedure is repeated until KT equals zero, at which point the next record is read and the process continues until an end of file is hit on the Merged Coincidence File, which causes JFLG to be set equal to one.

3.4.6 Block Data STDATMS

STDATMS predefines the pressure coordinate, the ZRANDIO record names for the spectral transmittances, and the central frequencies of the channels. Only the latter two variables need be attended to in running this program.

3.4.7 Subroutine TAURP

TAURP extracts from ECS the proper transmission functions as a function of season, latitude and zenith angle. It returns parameters, KND and IFLG. KND is the atmosphere model number, from one to five, of the atmosphere used. IFLG is an error return which is set equal to zero if a zenith angle of greater than 76 degrees is used.

3.4.8 Subroutine TRANW

TRANW corrects the transmission functions of the carbon dioxide channels for water by using Smith's (1969) polynomial approximation. If necessary it makes dimer and continuum corrections to the window channel, although this capability is not used here. Finally it makes a correction to the transmittances for the zenith angle dependence of path length.

4. UTILITY PROGRAMS

There were a number of ancillary programs written during the course of this project which were necessary for intermediate data treatment or for quality control. The more important programs are described here. It should be noted that some of these programs make use of plotting and microfiche hardware, and thus have limited portability.

4.1 PROGRAM COMPRAD

COMPRAD computes outgoing spectral radiance given a temperature and water vapor profile and a spectral transmission profile. The program presently performs computations based upon the seventy level standard atmosphere given in Table 5. The channel central frequencies are set in subroutine INIT. The pressure, temperature and water vapor profiles are read from logical unit TAPE1 using format (F10.4, E15.4, 15X, F10.3), and the spectral transmittances are read from logical unit TAPE2 using BUFFIO. There is a control switch set in the main program which allows water vapor transmission calculations to be skipped. Subroutine MIX, RADCOMP and TRANW are virtually identical to those described in Para. 3.4.

4.2 PROGRAM CVTAPE

The Atmospheric Absorption Line Parameter Compilation tape as provided by the National Climatic Center is not in the format which can be used by HITRAN. It is a coded tape and contains considerable extraneous information. CVTAPE reads the coded tape, strips out the unnecessary data, and writes a binary output tape. The result of this program is that I/O data handling by HITRAN is much improved.

4.3 PROGRAM LSTAU

Program LSTAU reads the BUFFIO format spectral transmittance file produced by program SPECTRN and produces an organized listing of all of the values. Titles are set by DATA statement in arrays LABL and VNU. It is important to note that this program produces about ninety pages of output, therefore, it is recommended that microfiche output be used.

4.4 PROGRAM LSTAUZ

LSTAUZ is very similar to LSTAU, the difference lies in the input data. LSTAUZ reads the ZRANDIO format spectral transmissivities produced by program ZTAU. The same caveat regarding output quantity in LSTAU also applies to LSTAUZ; microfiche output is recommended.

4.5 PROGRAM MKCOINC

MKCOINC makes a simulated satellite radiance file which will have positions coincident with an internally specified list of radiosonde locations. This is done by reading an arbitrary radiance file, and replacing the observation location with the station location, and the observation time with synoptic time. Matchups are performed in a pseudo random manner. Up to fifty radiosonde station locations may be specified in the program. This program is useful in testing the tuning programs described in Section 3.

4.6 PROGRAM PLTFILT

PLTFILT plots the instrument response functions. It produces six plots, one for each channel, and can plot the response of up to four different instruments on each. The filter functions are read in from logical units TAPE1 through TAPE4. Each filter function function set should consist of six groups of cards. The first card should have the lower and upper limits of the filter, the filter increment, and the filter central frequency in format (2F10.3, 2F10.4). The remaining cards in each group should have the filter values in format (9F8.4). The number of instruments to plot on each graph and the labels are set in DATA statements in the main program. Varian plot routines VCHAR, VCLEAR, VNUM, VOPEN, VP and VQ are used by this program but will not be described here. See Figure 1 for an example of PLTFILT usage.

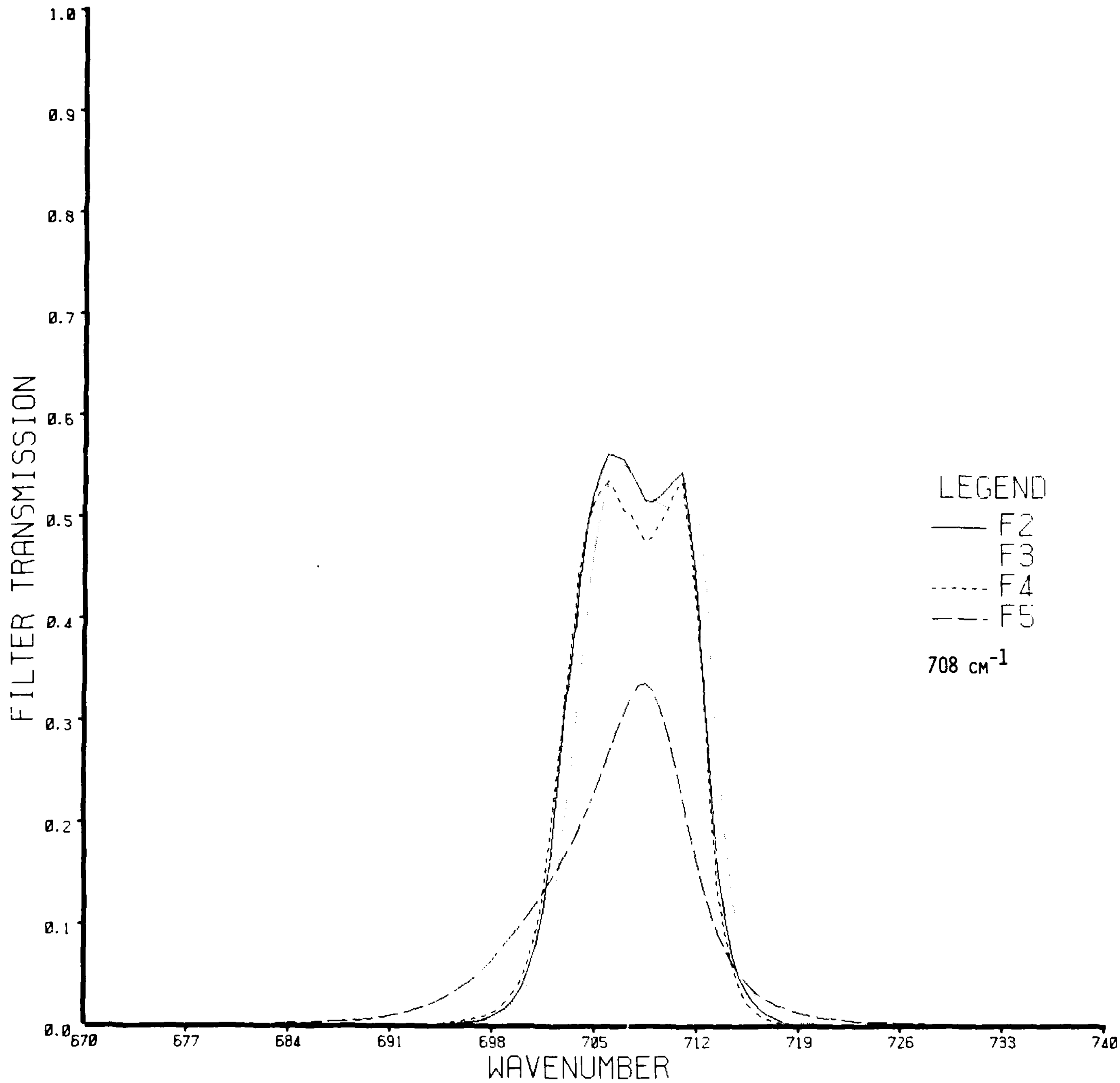

Figure 1. Example of Program PLTFILT output. Filter functions for DMSP Block 5D SSH instruments.

4.6.1 Subroutines for PLTFILT

DRWAXES draws the X and Y axes and lays down the tick marks. LEGEND writes the legend in the lower right corner. PLOTLIM finds the upper and lower limits of the X axis. PLT performs the actual plotting of the filter functions. TITLES labels the X and Y axes and labels the tick marks.

4.7 PROGRAM PLTTAU

PLTTAU plots up to four different spectral transmission profiles on the same graph using the Varian plot routines. It also computes and plots the weighting functions. The transmission profiles are read from logical units TAPE1-TAPE4 using format (9X, 5F14.8). The following control variables are set in DATA statements in the main program:

- MXTAU - the number of different transmission functions to be plotted, from one to four.
- IORDR - four element array specifying the order they are to be read in, e.g., if data was desired from units 4, 2, 3 in that order, the IORDR array would be /4, 2, 3, 0/ and MXTAU would be three.
- OPT - Plot control option, logical variable. TRUE plots all six channels of each model on the same plot. Produces MXTAU plots. FALSE plots the channel of all of the different profiles on the same graph. Produces six plots, one for each channel.
- LABELS - four element array for the legend labels, one word for each label.

Varian plot routine VCHAR, VCLEAR, VNUM, VOPEN, VP, VPUNT and VQ are used by this program but are described elsewhere, so will not be discussed here. The other subroutines will be described briefly in the following section. Examples of PLTTAU usage are given in Figures 2-3.

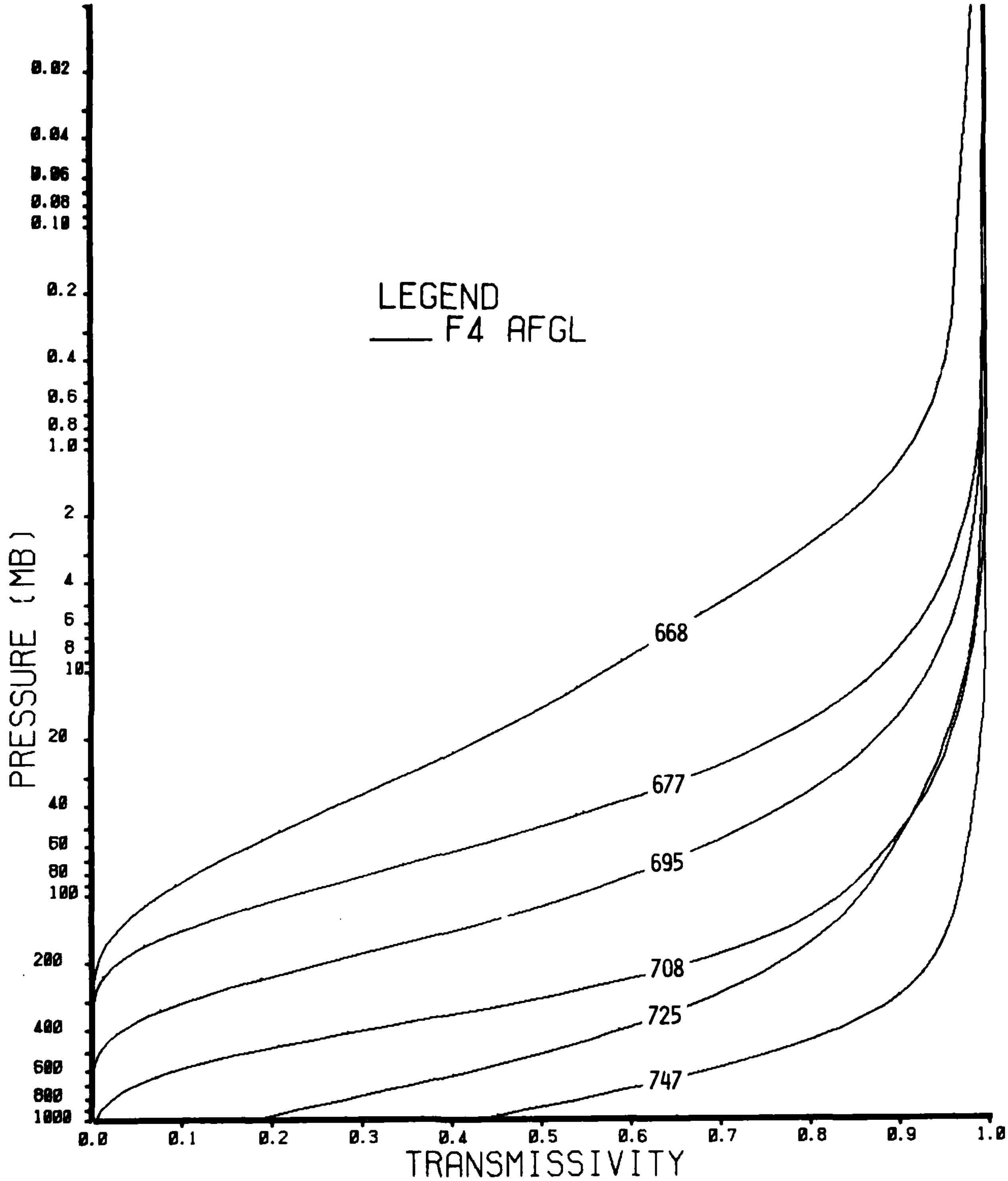

Figure 2a. Example of PLTTAU output with OPT = .TRUE. Transmission functions for DMSP F4 SSH for a dry tropical stmosphere with a zero degree zenith angle.

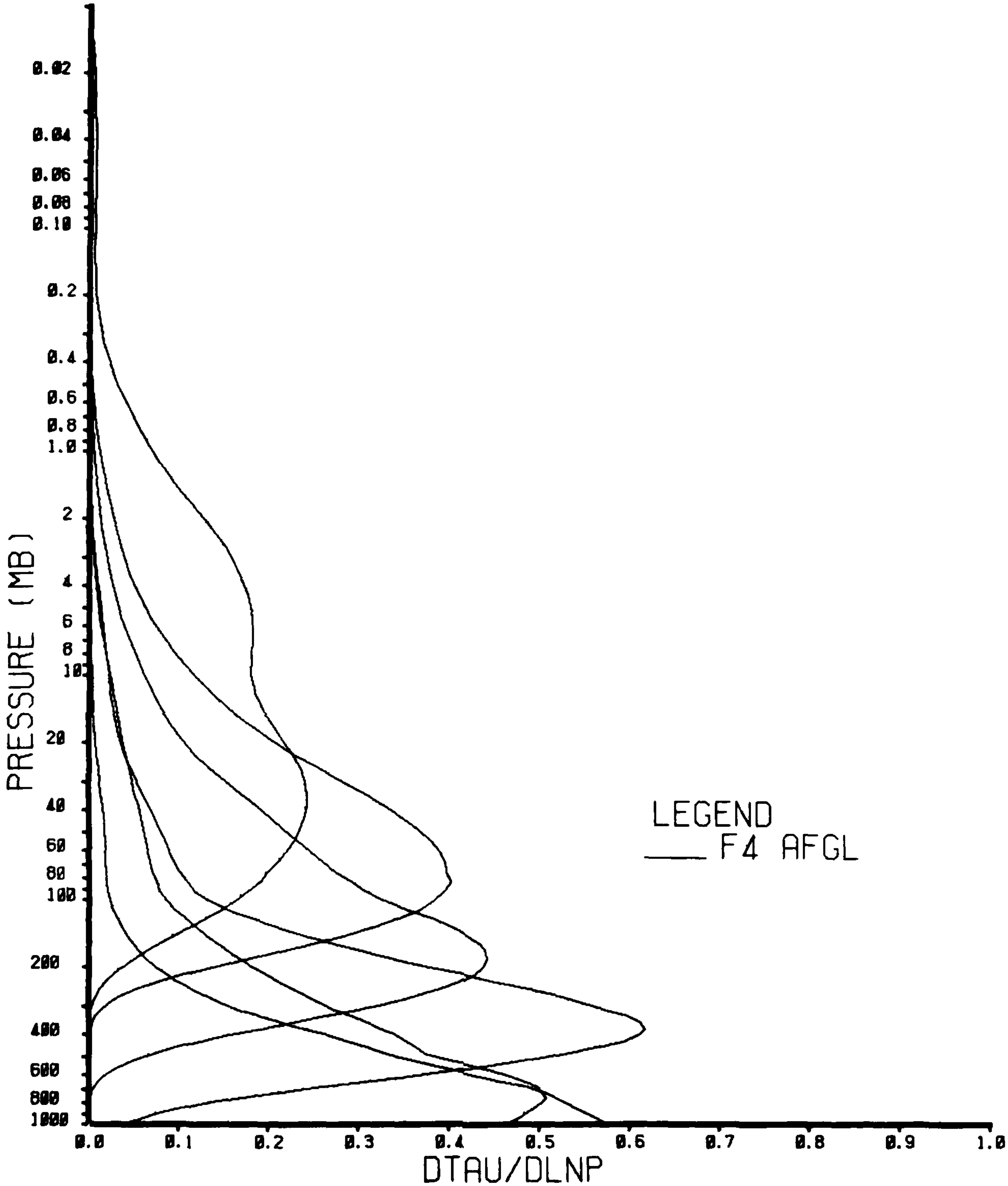

Figure 2b. Example of PLTTAU output with OPT = .TRUE. Weighting functions for DMSP F4 SSH for a dry tropical atmosphere with a zero degree zenith angle.

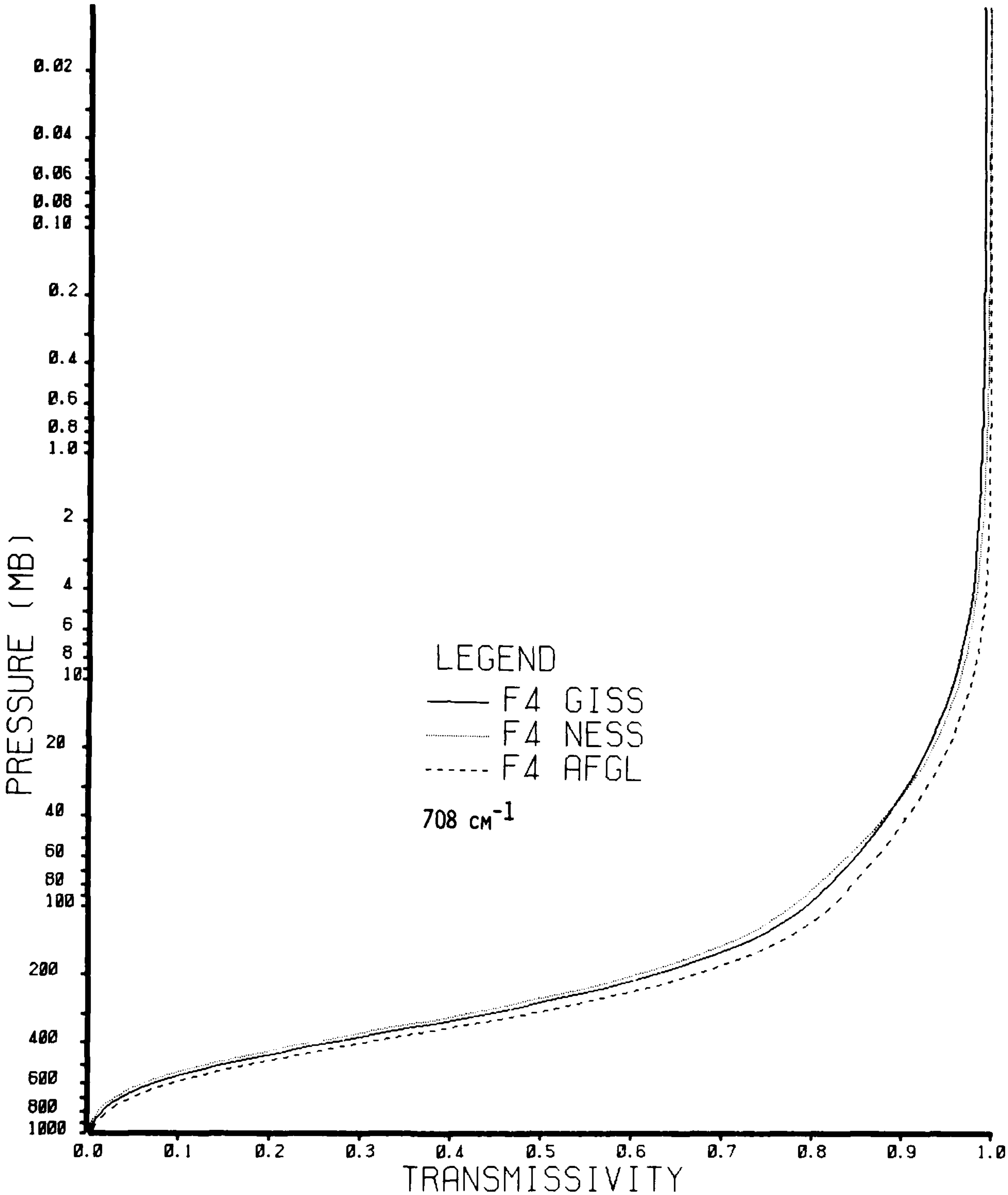

Figure 3a. Example of PLTTAU output with OPT = .FALSE. Transmission functions for DMSP F4 SSH for a dry tropical atmosphere with a zero degree zenith angle computed using three different techniques.

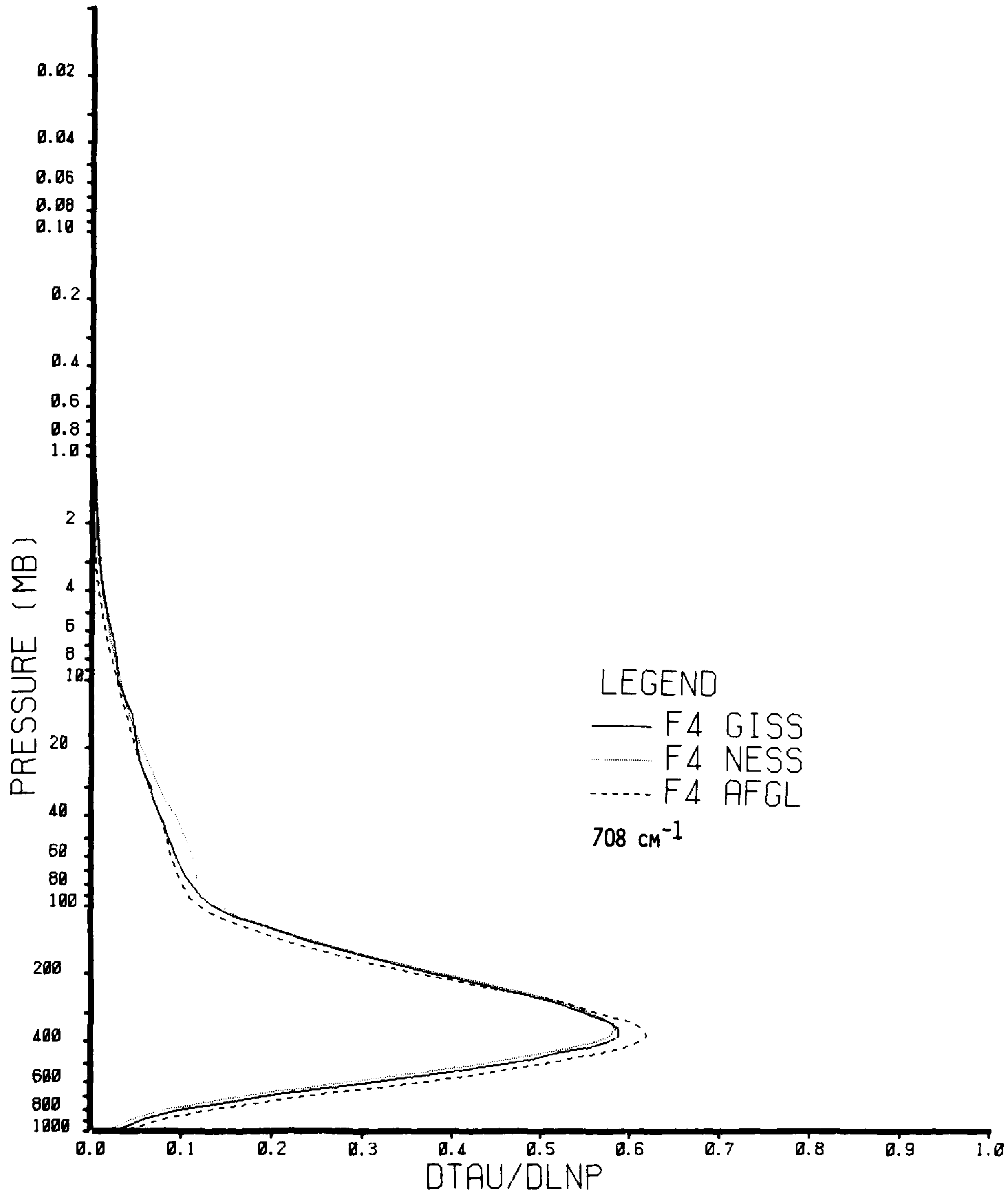

Figure 3b. Example of PLTTAU output with OPT = .FALSE. Weighting functions for DMPS F4 SSH for a dry tropical atmosphere with a zero degree zenith angle computed using three different techniques.

4.7.1 Subroutine for PLTTAU

DRWAXES draws the X and Y axes and labels the tick marks. The Y axis is scaled in log pressure.

LEGEND writes a legend in the lower right corner of the plot.

PLT performs the plotting of transmittance.

PLTDT computes and plots the weighting ($\frac{d\tau}{d\ln p}$).

TITLES labels the X and Y axes and labels the tick marks.

4.8 PROGRAM PLTTRAN

PLTTRAN reads the Monochromatic Transmittance Tape (Para. 1.3) and plots monochromatic transmissivity from 640 cm^{-1} to 780 cm^{-1}. It can plot up to four different atmospheric layers on the same plot. The control variables NLVL and LVLS are set in DATA statements in the main program. NLVL is the number of levels to plot, and LVLS is a four element array containing the level numbers from one to seventy, in ascending numerical order. Titles are specified internally. The Monochromatic Transmittance Tape is read directly from logical unit TAPE1. However, file and record positioning must be done by control cards. See Figure 4 for an example of PLTTRAN output.

4.8.1 Subroutine for PLTTRAN

DRWAXES draws the X and Y axes and lays down the tick marks.

PLT performs the actual plotting of the transmittances.

TITLES labels the axes and tick marks.

4.9 PROGRAM PLTTEMP

PLTTEMP plots up to four temperature profiles on the same graph using the Varian plot routines. The temperature profiles are read from logical units TAPE1 through TAPE4 using format (6X, F10.2). This program only plots temperature profiles which are layered in the seventy standard levels evenly spaced in p^k described in Table 5. Control variables MXPLT, LABELS and NCHR are set in DATA statements in the main program. MXPLT is the number of profiles to plot, between one and four. LABELS is a four element array containing the labels for the legend. NCHR

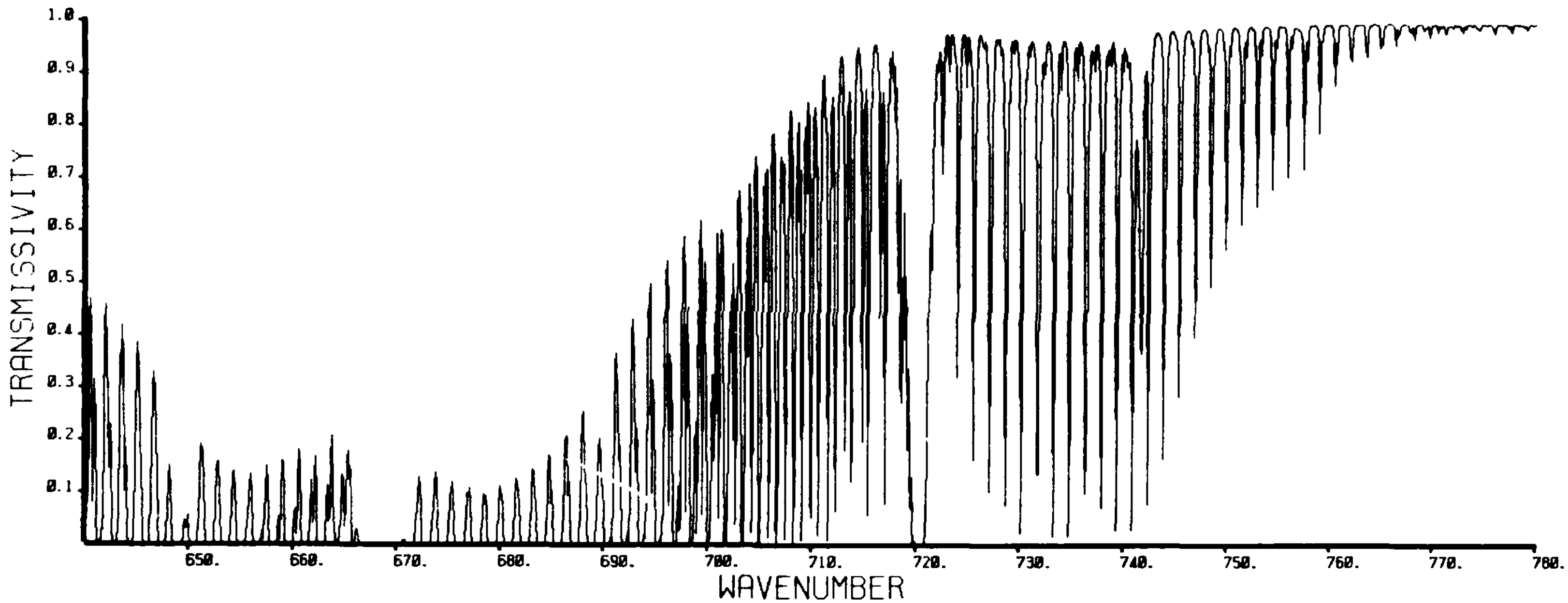

Figure 4. Example of PLTTRAN output. Monochrometric transmittance for a dry tropical standard atmosphere with a zero degree zenith angle.

is also a four element array containing the number of characters in each element of the LABEL array. Varian plot routines VCHAR, VCLEAR, VNUM, VOPEN, VP, and VQ are used by this program but are described elsewhere, so will not be discussed here. See Figure 5 for an example of PLTTEMP usage.

4.9.1 Subroutines for PLTTEMP

DRWAXES draws the X and Y axes and lays down the tick marks.
LEGEND writes a legend in the lower right corner of the graph.
PLT performs the actual plotting of temperature.
TITLES labels the axes and tick marks.

4.10 PROGRAM SETFRQ

SETFRQ generates the filter for HITRAN. The filters are square, .1 cm^{-1} wide with a value of unity. The filter values are written to logical unit TAPE1. Two cards are written for each filter. The first card has the starting and ending frequency of each filter, the half width (always 0.05), and the central frequency of the filter in format (2F10.3, F10.4, F10.3). The second card has the filter value of unity at the endpoints and midpoint of the filter in format (3F8.4). The control variables set in the main program are:

FSTART - starting wave number of the first filter.
FEND - ending wave number of the last filter.
DNU - wave number increment between filter centers.

4.11 PROGRAM SLCTLIN

Disk storage is used exclusively in the HITRAN runs to speed data access and improve turnaround. However, if the entire Atmospheric Absorption Line Parameter Tape were loaded to disk, the resource allocations would be prohibitive. Program SLCTLIN selects only the line structure data that HITRAN will use and discards the rest. Input to SLCTLIN is the Binary Line Structure Tape on logical unit TAPE1, output is on logical unit TAPE2,

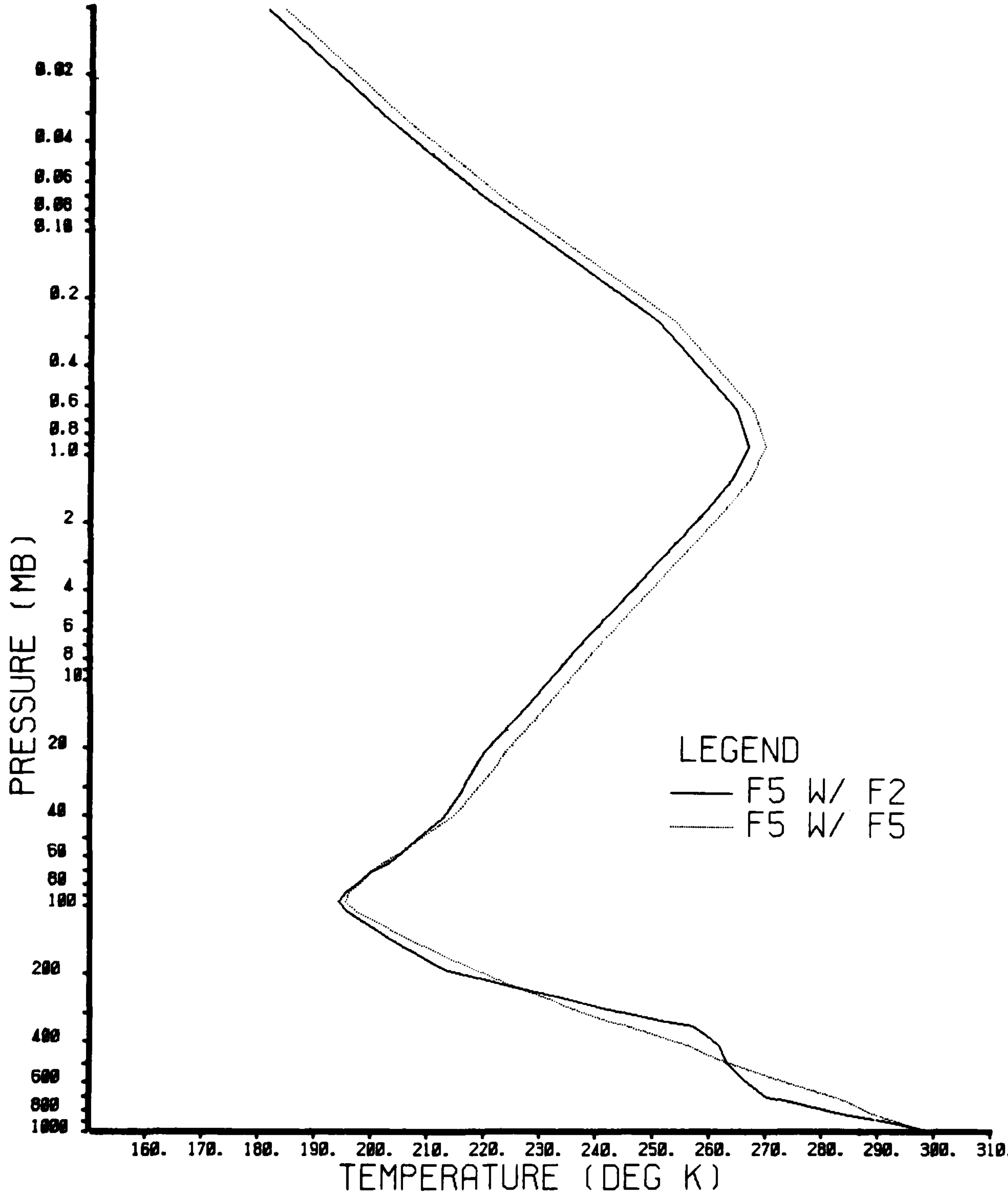

Figure 5. Example of PLTTEMP output. Retrieved temperature profiles using computed radiances. F5 W/ F2 means retrieved using F5 and F2 radiances. The curve labeled F5 W/ F5 is the correct solution.

with the identical format. All I/O is done using FORTRAN binary read/write. The following control variables are used:

ANUMIN - initial wave number of data to be selected.

ANUMAX - final wave number of data to be selected.

MFILE - number of files on the tape.

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Smith, W. L., 1969: A polynomial representation of carbon dioxide and water vapor transmission. ESSA Technical Report NESC 47, Environmental Science Services Administration, U.S. Department of Commerce, Washington, DC, 20 pp.

Note: Program GETRAOB was written by James Clark of NAVENVPREDRSCHFAC. Program HITRAN was written by McClatchey _et al_. (1973). All other programs were written by the author of this technical report.

LIST OF ACRONYMS AND SELECTED NAMES

AFGL	-	Air Force Geophysics Laboratory, Hanscom AFB, MA
ATGS	-	Atmospheric Transmission Generation System
BUFFIO	-	CDC system routines allowing for high speed I/O to/from disk or tape.
CDC	-	Control Data Corporation
DMSP	-	Defense Meteorological Satellite Program
FNOC	-	Fleet Numerical Oceanography Center, Monterey, CA
I/O	-	Input/Output
MTT	-	Monochromatic Transmittance Tape
NEPRF	-	Naval Environmental Prediction Research Facility Monterey, CA
RAOB	-	Radiosonde Observation
SSH	-	Supplementary Sensor H - multispectral infrared sensor flown on DMSP satellites
SPADS	-	Satellite Processing and Display System at NEPRF based upon Data General ECLIPSE/NOVA
SPC	-	Satellite Processing Computer ("SPOCK") at FNOC, a CDC CYBER175
Varian	-	Brand name of electrostatic plotter
ZRANDIO	-	Random access I/O system written and used at FNOC

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